The Influence of Cultural Conditions on the Severity of Mature Watermelon Vine Decline

The primary goal of our research on mature watermelon vine decline (MWVD) is to help watermelon growers manage the disease. While a “cure” for MWVD will probably require understanding the biology behind the disease, it may be possible to lessen the impact of MWVD on watermelon growers by understanding the cultural conditions under which MWVD becomes severe. Several cultural factors are suspected of involvement in MWVD.

- Field observations of MWVD suggest that soil moisture may play a role in the severity of MWVD. Severe outbreaks of MWVD have occurred in years when rainfall was heavy (Table 1). Initial outbreaks of MWVD seem to occur shortly after a heavy rain. MWVD appears to show up in fields with heavier soils than in lighter sands. When MWVD does start in a field, it usually starts in low areas where water has accumulated. Finally, data from the greenhouse section of this report seem to support the hypothesis that high soil moisture is associated with more severe outbreaks of MWVD. Careful irrigation management may help growers to control MWVD.
- It is difficult to gauge the significance of black plastic mulch on the severity of MWVD since this cultural adaptation now dominates grower practice. However, the incidence of MWVD seems to have increased along with the adoption of black plastic mulch in watermelon culture. MWVD has never been observed on watermelons planted on bare ground.
- Fumigation has long been used as a management practice for many soil borne problems of vegetables. Although MWVD appears to be a soil borne problem, MWVD has been observed in fumigated as well as non-fumigated fields. Our research has shown that the biological factor(s) that cause MWVD can be removed by a controlled fumigation in the greenhouse. Therefore, soil fumigation may fail to lessen the symptoms of MWVD because of inadequate fumigation conditions and/or some areas of the watermelon root zone remain non-fumigated under current practices.
- Although large differences in the susceptibility of watermelon varieties to MWVD have not been observed, some differences have been reported, for example, between seedless (triploid) and seeded (diploid) varieties. If differences do exist in varietal susceptibility, this would be a way that growers would be able to change their practices to lessen the impact of MWVD.
- Since evidence suggests that the biological factor(s) involved in MWVD are soil borne, those factors affecting watermelon root characteristics may affect MWVD

Materials and Methods

Effects of Cultural Practices

Field experiments. Seeds of watermelon cultivars Royal Sweet (diploid hybrid) and Millionaire (triploid hybrid) were planted in single cell flats containing Jiffy Mix Plus in the greenhouse.

A multi-factorial experiment was conducted in a sandy loam soil (79% sand, 15% silt, 5% clay) with a history of MWVD in 2001 and 2002. Seedlings (2 to 3 leaf stages) of the respective cultivars were transplanted at 1.1m intervals to yield 14 plants/plot on single row mulched [1.2 m wide x 2-mil thick black plastic (Visqueen 4020)] plots measuring 15 m in length and spaced 1.7 m apart. Fumigation was done in blocks using methyl bromide-chloropicrin (2:1) (398 kg/ha). Treatments were arranged as a split-block/split-plot with fumigation and irrigation as blocks, and mulch x variety as sub-sub-plots. All treatments were replicated four times. Irrigation was applied to plots using a single drip irrigation line with emitters spaced 40 cm apart and placed below the mulch on each plot. Plots receiving irrigation were watered at a rate of 5.3 L/min/30.3 m of row at a pressure of 69 kPa. Irrigation was applied for 8 to 10 h each time/ 3-4 day interval during the experiment. Non-irrigated plots were watered approximately till flowering, then were cut-off from irrigation for the duration of the experiments.

Data collection. Four samplings of crowns and roots were made starting one month after transplanting at three-week intervals. One random plant/replication was collected to assess crown and root rot severities based on a 0 to 5 scale where 0 = no crown or root rot, 1 = 1 to 20% crown or root rot, 2 = 21 to 40% crown or root rot, 3 = 41 to 60% crown or root rot, 4 = 61 to 80% crown or root rot, and 5 = > 81% crown or root rot. Following disease assessment, 5 0.2-cm bits of crown, taproot and secondary root were disinfected in 0.5% sodium hypochlorite, washed twice in sterilized distilled water and plated on potato dextrose, Nash-Synder, and $P_{10}VP$ media, respectively to determine the total number of fungal species, *Fusarium* species, and *Pythiaceuos* species, respectively. After three days incubation in dark at $25 \pm 2\ ^{o}$ C, plates were recorded for the different fungi.

In addition, data on plant stand, vine length, plant health (scored on 0 to 5 scale where 0 = no vine death, 1 = 1 to 20% vine death, 2 = 21 to 40% vine death, 3 = 41 to 60% vine death, 4 = 61 to 80% vine death, and 5 = > 81% vine death), number and weight of marketable fruit were also taken (two harvests).

Effect of Seeding vs. Transplanting

Field experiments were conducted in two locations during the growing season of 2002 to understand the impact of direct seeding and transplanting, and mulching on the severity of MWVD. The experiments were laid out as RCBD with four-replications/ treatment/location. Experimental units were single row plots measuring 15 m in length and spaced 1.7 m apart. The plots were either mulched with 1.2 m wide x 2-mil thick black plastic (Visqueen 4020) or non-mulched. Planting dates of direct seeding and transplanting were adjusted so has to have relatively close physiological age of the plants. For the direct seeded plots, each hole was seeded with four seeds and later thinned to one after germination. The seeded plots were watered regularly to facilitate germination. There were 14 plants/plot for both direct seeded as well as transplanted plots at the start of the experiment. The soil texture in both locations was predominantly loamy sand. The cultivar used was A & C 800 "SummerFlavor".

Data collection. At the conclusion of the experiment, plant stand was taken; plots were scored for vine health (as previously described), and three plants/replication was scored for crown rot and root rot (as previously explained). Marketable fruit number and marketable fruit weight also was recorded at the end of the experiment.

Statistical analysis. The experimental design was randomized complete block with four replications. Data were analyzed using General Linear Models of SAS (SAS Institute, Cary, NC). Significance of the main factors were tested using appropriate error terms while the interaction effects were tested using pooled error terms. Treatment means were compared using Fisher's Least Significance Test at $P = 0.05$.

Results

In contrast with the year 2000, relatively little MWVD was observed in commercial watermelon fields in southern Indiana. The probable reason is the relative lack of rain fall during the months of June, July and August in 2001 and 2002 (Table 1).

Table 1: Rainfall in inches for the years 2000 through 2002 and the 30-year mean for comparison. Mature watermelon vine decline was severe in the year 2000, whereas in the years 2001 and 2002 little MWVD was observed.

	Year			
Month	**2000**	**2001**	**2002**	**30-year mean**
May	3.9 [a]	2.1	10.3	5.0

Plants that were mulched had more vine death and longer vines in both years of the study (Figure 1, Table 2 and 3). In 2001, mulched plants had greater yields than non-mulched.

Fumigated

Non-Fumigated

Figure 1: Watermelon vines growing in plots fumigated with methyl bromide/chloropicrin (top photo) or non-fumigated (bottom photo). The plots on the left in each photo had black plastic mulch, while the plots on the right were non-mulched.

Root and microbiological data. In both years, root rot and crown rot became worse with each sampling date (Table 4). Fumigation had no effect on root and crown rot in 2001, but in 2002, both types of rot were more severe in non-fumigated soils (Table 4 and 5).

Influence of method of propagation and mulch-Watermelon vines were healthier when seeded than transplanted in both locations (Table 5). Mulched plants had healthier vines in Field N, but there was no difference in vine health in Field E. No difference in crown or root rot was noted due to mulching or propagation method. Similarly, little difference was observed in fruit yields.

Table 2. Influence of fumigation, irrigation, variety, and mulch on plant health, vine length, plant stand, marketable fruit number/ha, and marketable weight/ha in a field affected by watermelon vine decline, 2001.

Factors	**Plant Health** [z]	**Vine Length (cm)**	**Plant Stand (#/ha)**	**Marketable Fruit (#/ha)**	**Marketable Fruit Weight (kg/ha)**
Fumigation:					
Fumigated	2.8 a[y]	124.4 a	2405 a	3040 a	53452 a
No Fum.	2.3 b	77.8 b	2291 a	749 b	10147 b
Irrigation:					
Irrigated	2.7 a	101.5 a	2246 a	1906 a	31242 a
No Irri.	2.4 b	100.6 a	2450 a	1883 a	32352 a
Variety:					
Millionaire	2.6 a	91.0 b	2223 a	1804 a	26204 b
Royal Sweet	2.5 a	111.2 a	2473 a	1985 a	37395 a
Mulch:					
Mulched	2.7 a	119.3 a	2496 a	2223 a	36198 a
No Mulch	2.4 b	82.8 b	2201 a	1565 b	27401 b

[z] Plant health was scored on a 0 to 5 scale with 0 = no vine death and 5 - > 81% of the vines dead.

[y] Values in columns within each factor followed by the same letter is not significantly different at *P* = 0.05 according to Fisher's Least Significant Difference Test.

Table 3. Influence of fumigation, irrigation, variety, and mulch on plant health, vine length, plant stand, marketable fruit number/ha, and marketable weight/ha in a field affected by watermelon vine decline, 2002.

Factors	Plant Health[z]	Vine Length (cm)	Plant Stand (#/ha)	Marketable Fruit (#/ha)	Marketable Fruit Weight (kg/ha)
Fumigation:					
Fumigated	2.2 a[y]	96.2 a	4980 a	6001 a	81403 a
No Fum.	2.4 a	91.8 a	4764 a	4095 b	54382 b
Irrigation:					
Irrigated	2.4 a	88.4 a	4889 a	4912 a	70002 a
No Irri.	2.4 a	96.6 a	4855 a	5184 a	65782 a
Variety:					
Millionaire	2.1 a	92.8 a	4810 a	5831 a	73133 a
Royal Sweet	2.5 a	95.3 a	4935 a	4265 b	62652 a
Mulch:					
Mulched	2.6 a	102.9 a	4912 a	5150 a	68244 a
No Mulch	2.0 b	85.2 b	4832 a	4956 a	67541 a

[z] Plant health was scored on a 0 to 5 scale with 0 = no vine death and 5 - > 81% of the vines dead.

[y] Values in columns within each factor followed by the same letter is not significantly different at *P* = 0.05 according to Fisher's Least Significant Difference Test.

Table 4. Influence of sampling, fumigation, irrigation, variety, and mulch on crown rot, root rot, mean colony counts of total fungi, *Fusarium* spp., and *Pythiaceous* spp. isolated from plant parts in a field affected by mature watermelon vine decline, 2001.

	Crown rot [z]	**Root rot** [z]	**Total Fungi**	**Fusarium spp.**	**Pythiaceous spp.**
Sampling:					
Time 1	0.3 b [y]	0.3 c	19.2 c	3.6 c	4.2 d
Time 2	0.5 b	0.6 b	24.1 ab	11.3 ab	8.9 c
Time 3	1.5 a	1.8 a	24.6 a	11.8 a	10.7 b
Time 4	1.5 a	2.0 a	23.2 b	10.4 b	12.1 a
Fumigation:					
Fumigated	0.9 a	1.1 a	23.5 a	9.1 a	8.5 a
No Fum.	1.0 a	1.1 a	22.1 b	9.5 a	9.5 b
Irrigation:					
Irrigated	1.2 a	1.3 a	22.8 a	9.6 a	9.6 a
No Irri	0.8 b	1.0 b	22.7 a	9.0 a	8.6 b
Variety:					
Millionaire	1.2 a	1.3 a	24.0 a	9.9 b	9.3 a
Royal Sweet	0.7 b	1.0 b	22.0 b	8.6 a	8.7 a
Mulch:					
Mulched	1.3 a	1.4 a	23.9 a	9.5 a	10.5 a
No Mulch	0.6 b	0.9 b	21.6 b	9.1 a	7.5 b

[z] Crown and root rots were scored on a scale of 0 to 5, with 0 – no crown or root rot and 5 = > 81% crown or root rotted.

[y] Values in columns within each factor followed by the same letter is not significantly different at
P = 0.05 according to Fisher's Least Significant Difference Test.

Table 5. Influence of sampling, fumigation, irrigation, variety, and mulch on crown rot, root rot, mean colony counts of total fungi, *Fusarium* spp., and *Pythiaceous* spp. isolated from plant parts in a field affected by mature watermelon vine decline, 2002.

	Crown rot [z]	**Root rot** [z]	**Total Fungi**	**Fusarium spp.**	**Pythiaceous spp.**
Sampling:					
Time 1	0.3 d [y]	0.1 d	16.8 a	4.5 a	2.9 b
Time 2	0.5 c	0.3 c	16.9 ab	3.3 b	1.6 c
Time 3	0.7 b	0.8 b	14.8 b	4.9 a	1.9 c
Time 4	0.9 a	0.9 a	18.2 a	4.9 a	4.6 a
Fumigation:					
Fumigated	0.2 b	0.3 b	14.9 b	2.9 a	1.5 a
No Fum.	1.0 a	0.7 a	18.5 a	5.9 b	4.1 b
Irrigation:					
Irrigated	0.7 a	0.5 a	16.2 a	4.0 b	2.8 a
No Irri	0.5 b	0.5 a	17.2 a	4.8 a	2.8 a
Variety:					
Millionaire	0.8 a	0.6 a	17.6 a	5.5 a	3.1 a
Royal Sweet	0.4 b	0.4 b	15.7 b	3.3 b	2.4 b
Mulch:					
Mulched	0.6 a	0.5 a	16.4 a	4.0 b	2.5 a
No Mulch	0.6 a	0.5 a	16.9 a	4.8 a	3.0 a

[z] Crown and root rots were scored on a scale of 0 to 5, with 0 – no crown or root rot and 5 = > 81% crown or root rotted.

[y] Values in columns within each factor followed by the same letter is not significantly different at $P = 0.05$ according to Fisher's Least Significant Difference Test.

Table 6. Influence of planting method and mulching on vine health, vine length, plant stand, crown rot, root rot, marketable fruit number, and marketable fruit yield in fields affected by mature watermelon vine decline in 2002.

Factors	Vine Health *	Plant Stand # ha^{-1}	Crown Rot **	Root Rot **	Marketable Fruit Number ha^{-1}	Marketable Fruit Weight kg ha^{-1}
Field E						
Seeded	2.4 a	3312 b	1.2 a	1.1 a	3630 a	74733 a
Transplanting	1.4 b	4492 a	0.8 a	0.6 a	3675 a	50684 b
Mulch	2.0 a	3857 a	1.1 a	1.0 a	3393 a	67563 a
No Mulch	1.8 a	3948 a	0.9 a	0.7 a	3312 a	57853 a
Field N						
Seeded	3.3 a	4129 b	0.1 a	0.2 a	3040 a	61347 a
Transplanting	2.5 b	5037 a	0.03 a	0.3 a	3040 a	46555 a
Mulch	3.3 a	4628 a	0.03 a	0.3 a	3040 a	55811 a
No Mulch	2.6 b	4538 a	0.1 a	0.2 a	3040 a	52091 a

* Vine health scored on a 0 to 5 relative scale where 0 = no vine death and 5 = greater than 81% of the vines dead.

** Crown and root rot scored on 0 to 5 relative scale where 0 = no crown or root rot and 5 = greater than 81% crown or root rotted.

*** Values followed by different letters within each factor is significantly different at *P* = 0.05 according to Fisher's Least Significant Test.

Discussion

Fumigation boosted yields in both years, even in the absence of significant MWVD or any other soil borne problems. This conclusion is in agreement with other experiments where fumigation was associated with a yield increase in the absence of significant soil borne disease problems. Fumigation may eliminate fungi that damage fine roots. Although such damage may not show up as wilt or root rot, watermelon plants grown under fumigated conditions where such “root nibblers” do not occur consistently out yield watermelon plants grown in non-fumigated soil.

Field observations that MWVD occurs only under black plastic were validated by both years of this study. The presence of black plastic mulch resulted in more vine death from MWVD. Longer vines also resulted from plants grown in plastic culture. The increase in severity of MWVD under black plastic may be due to an increase soil moisture and temperature.

Most watermelon growers find it necessary to use black plastic to speed maturity of fruit, for weed control and to maintain moisture in the root zone of the watermelon plants. It may be difficult for many growers to stop using black plastic mulch altogether, however, it may be useful to try to modify the environment of the root zone so that less root death occurs. Alternatives may include other types and colors of plastic.

Although no clear difference in the amount of vine death was apparent for Millionaire or Royal Sweet in either 2001 or 2002, Millionaire had significantly more root rot, crown rot, total fungi and *Fusarium* spp. than Royal Sweet in both years.. It may be possible that Millionaire would have shown greater susceptibility to MWVD than Royal Sweet in a year when more disease pressure existed.

Irrigation did not cause a consistent increase in the severity of MWVD. In contrast, field observations and greenhouse tests support the hypothesis that high soil moisture enhances the severity of MWVD. Trickle irrigation may not supply a sufficient volume of water to increase the severity of MWVD in a year with normal to low amounts of rainfall.